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SMART FABRICS AND EMOTIONAL DESIGN: THE INTERACTION OF TECHNOLOGY AND HUMAN PERCEPTION IN FASHION

Abstract

The relevance of the study is determined by the rapid introduction of "smart" fabrics into fashion design, which requires scientific understanding of their impact not only on the functionality of clothing, but also on the emotional and psychological experience of a person. The purpose of the article is to identify the mechanisms of influence of innovative materials with dynamic properties on the emotional reactions of users and to substantiate the conceptual guidelines for their integration into fashion design, taking into account human psychological sensitivity. The research methodology is based on an interdisciplinary approach and combines theoretical analysis of scientific sources, systematization of types of innovative fabrics, comparative analysis of sensory characteristics of materials, and conceptual generalization of the principles of emotional design. The study found that the evolution of "smart" fabrics in fashion consists in changing the role of the material from a passive form carrier to an active communicative element of interaction with the user. The main types of innovative materials (self-heating, color-changing, responsive fabrics) were systematized and their dominant sensory channels of influence were identified. It has been found that the dynamic properties of fabrics form different emotional reactions, in particular comfort, a sense of security, control, and novelty, the intensity of which depends on the predictability and dosage of changes. It has been proven that excessive or opaque material dynamics can cause emotional tension, while understandable logic of

reactions contributes to trust in clothing. Conceptual guidelines for the integration of technological innovations into fashion design have been substantiated. The practical significance of the results lies in the possibility of their use by designers and developers of “smart” clothing to create emotionally supportive, safe, and human-centered design solutions, as well as in forming a methodological basis for further empirical research on user experience in the field of innovative fashion.

Keywords

Visual aesthetics, functional expediency, interactive environment, comfort, subjective experience.

Introduction

The rapid introduction of “smart” fabrics into modern fashion is gradually changing the very concept of clothing as a passive object of consumption. Materials that can react to body temperature, humidity, light, or the emotional state of the user take design practice beyond visual aesthetics and functional expediency. Clothing is increasingly acquiring the properties of an interactive environment that enters into direct dialogue with the human body and psyche [1]. However, the speed of technological development significantly outpaces the theoretical understanding of how these materials affect emotional perception, comfort, and subjective human experience.

In scientific and applied research, innovative fabrics are predominantly viewed through the prism of engineering characteristics: energy efficiency, durability, accuracy of sensory responses, or environmental friendliness of production. The emotional dimension of their use often remains secondary or is reduced to general statements about “increased comfort” or “improved user experience” [2]. At the same time, it is the emotional response—the feeling of warmth, safety, surprise, play, or control—that determines whether

technologically complex clothing will be accepted by the user and integrated into everyday life.

Particular attention should be paid to the contradiction between the growing complexity of responsive fabrics and the limited number of studies analyzing how changes in color, temperature, or tactile properties of fabric are perceived by humans at the level of sensations and emotional associations [3]. Technological reactivity does not always automatically mean a positive experience. For some users, dynamic color or self-heating may be perceived as innovation and care, while for others, it may be a source of anxiety or loss of control over their own physical space. This ambiguity is practically not reflected in contemporary concepts of fashionable design.

In contemporary scientific discourse, the issue of "smart" fabrics increasingly goes beyond engineering and materials science approaches and is gradually being integrated into the field of research on human interaction with technologies. The work of M. Guennes et al. [1] demonstrates that the development of smart textiles is accompanied by a shift in focus from individual material solutions to the user experience. The authors establish that most modern developments are focused on technical efficiency and functionality, while the emotional and sensory aspects of interaction remain fragmentarily described, without a single conceptual framework.

This trend is confirmed by a bibliometric analysis conducted by I. Sajovic et al. [2], which shows that the bulk of research is focused on the classification of technologies and areas of application for smart textiles. At the same time, the authors note an insufficient number of works devoted to the interpretation of user experience and the influence of the dynamic properties of the material on perception, behavior, and emotional reactions. This imbalance indicates a need for interdisciplinary analysis that would combine design, psychology, and materials science.

An important shift towards a body-oriented approach is demonstrated by A. Tajadura-Jiménez et al. [3]. The authors establish that electronic and tactile fabrics can change the perception of one's own body through sensory metaphors, affecting the sensation of spatial boundaries and movement. The results show that the material can interfere with a person's body schema and thus indirectly influence their emotional state.

An analysis of current achievements in the field of smart fabrics, proposed by H. L. O. Júnior et al. [4], confirms the high level of technological maturity of many innovative materials. The authors emphasize that the key challenges are not so much technical limitations as issues of user acceptability, stability of sensory impact, and possible emotional overload.

A direct link between smart textiles and emotional regulation can be traced in the work of M. Jiang et al. [5]. The authors establish that motion-oriented interaction with smart textiles can contribute to changes in users' emotional states, in particular through feelings of engagement and physical activity. At the same time, the emotional effect is considered primarily as a consequence of the interactive scenario, rather than as a result of the design integration of the material into clothing.

The cultural and narrative dimension of “smart” textiles is revealed by I. Posch [6], who demonstrates that electronic fabrics are capable of conveying meaning and forming emotional engagement through tactile and visual qualities. The author concludes that the material can be a carrier of history and emotional experience, not just a technical element.

The theoretical basis for rethinking these processes is provided by the results of J. Tan et al. [7], which demonstrate the potential of gesture-controlled light textiles as an interactive environment. The authors establish that the combination of computer vision and textile structures allows the material to respond to user actions in real time, creating a sense of control and engagement. However, the

emotional consequences of such interaction are considered indirectly, without a clear connection to human psychological sensitivity.

A theoretical basis for rethinking these processes is proposed by A. G. Lopes [8], who outlines the evolution of approaches in human–computer interaction from functionality to experience- and emotion-oriented design. His conclusions allow us to interpret “smart” fabrics as part of a broader shift in interaction design, where physical and emotional experiences are becoming key.

The material science aspect of dynamic fabrics is covered in detail in J. Cheng's review [9], which shows that color-changing textiles can combine thermoregulation with visual communication. The authors emphasize the potential of such materials as signaling systems, but do not analyze how the constant visibility of changes affects the emotional comfort or tension of the user.

The psychological context relevant to the interpretation of emotional responses to “smart” fabrics is outlined in a study by P. Li [10]. The authors establish a close link between feelings of stress, control, and depressive states, emphasizing the role of a supportive environment in reducing psychological stress.

Thus, analysis of scientific sources indicates the existence of significant theoretical and empirical work on smart textiles technologies, but reveals insufficient attention to a systematic understanding of their emotional impact in the context of fashion design. It is this gap—between the technical capabilities of materials and the psychological experience of the user—that determines the relevance and scientific novelty of the presented research.

The purpose of the article is to identify and conceptually justify the mechanisms of influence of innovative adaptive fabrics on the formation of the user's emotional experience in modern fashion design.

Research Results

For a long time, fabric remained an almost invisible participant in the design process. Its presence was necessary but silent [11]. Fabric served as a stable

foundation that ensured the fixation of the form, color, and silhouette intended by the designer.

Table 1

Evolution of approaches to the use of fabrics in fashion: from passive material to active communicative element

The dominant understanding of the role of material	Key properties of fabric	Nature of interaction with the user	Type of emotional impact
Traditional fashion			
Passive carrier of form and image	Stability, inertia, predictability	Mediated interaction through form, color, and style	Emotions are formed symbolically and culturally
Functional textiles			
Material as a technical tool	Thermoregulation, moisture wicking, wear resistance	Physical contact without obvious reciprocal reaction	Comfort as a utilitarian sensation
Adaptive fabrics			
Material as a responsive environment	Ability to change properties depending on conditions	Partial interaction, reaction is hidden or barely noticeable	Subconscious feeling of comfort
Reactive ("smart") fabrics			
Active participant in interaction	Change in color, temperature, texture in real time	Direct sensory and visual communication	Conscious emotions of novelty, control, or tension
Communicative material in fashion			
Material as a carrier of meanings and signals	Interactivity, dynamism, personalization	Constant dialogue between body, fabric, and environment	Complex emotional experience (safety, play, care)

Source: author's own development

It had to be reliable, predictable, and devoid of “character.” It was in this predictability that its value was seen. The emotional impact of clothing was shaped mainly through visual images, stylistic references, and cultural codes,

while the material remained a backdrop on which the designer's idea unfolded, but not its active carrier.

The gradual emergence of functional and technical textiles was the first step toward breaking this established logic. Fabric began to perform tasks that went beyond aesthetics: retaining heat, regulating the microclimate, adapting to physical exertion [2]. It “learned to work.” However, even in this format, the material remained more of a tool than a participant in interaction. Its functionality was hidden, almost invisible to the user, and its contact with the body was utilitarian. Comfort was felt but not articulated. The fabric acted without entering into dialogue.

A qualitative shift occurs with the advent of adaptive and reactive materials capable of changing their own properties in response to external or bodily signals. In this case, the fabric no longer just adapts – it demonstrates its reaction [12]. Color, temperature, and texture become variable parameters that the user can observe and feel. Clothing ceases to be a finished object and begins to exist as a process that unfolds over time. It is here that the material first asserts itself as an active element of experience, rather than a neutral carrier of form.

This transformation inevitably changes the concept of design authorship. When the material acquires the ability to respond, control over the final appearance of the product becomes partial. The designer sets not the form, but the conditions. Not the result, but the scenario. The final aesthetic arises from the interaction between the user's body, the environment, and the fabric, which does not always behave in the same way [9]. In such a model, the material ceases to be a resource and begins to function as a carrier of behavior and meaning.

At this stage, it is appropriate to talk about the emergence of a communicative dimension of fabric. “Smart” material does not simply react – it communicates. It communicates about changes in temperature, body tension, movement, or contact with the environment. This communication is not

verbalized, but is read at the level of sensations and visual signals [8]. That is why adaptive fabrics are approaching the logic of emotional design, where it is not only what an object does that is important, but also how it makes a person feel. That is why the key analytical parameter is not the principle of the fabric's action, but the nature and manner of its perception by a person – through warmth, sight, touch, and changes in physical condition over time.

Self-heating materials form a separate group, whose sensory effect is primarily associated with the thermal channel of perception [13]. Unlike traditional insulators, these fabrics create a regulated rather than a static thermal background that responds to environmental conditions or body parameters. The sensation of warmth in this case is not sharp or demonstrative. It is gradual, almost imperceptible, but long-lasting. It is this “quiet” sensibility that forms a specific emotional effect – a feeling of security, stability, and physical comfort. Self-heating fabrics affect the overall emotional state rather than immediate reactions, which makes them important for analyzing background emotions in everyday wear.

Another type of innovative material – color-changing fabrics – works on the opposite logic. Their sensory effect is visual and open. A change in color or shade due to temperature fluctuations, lighting, or touch transforms the material into a visible indicator of processes that usually remain hidden [14]. In this case, the fabric does not simply react, but demonstrates its reaction. Visual variability attracts attention, provokes interpretation, and evokes emotions of novelty, play, or surprise. At the same time, such sensory openness can also create tension, as the material makes bodily or environmental states public and visible.

The most complex in terms of sensory organization is the category of responsive fabrics. These materials combine several types of reactions and, accordingly, several channels of perception [12]. A change in temperature may be accompanied by a transformation of texture, stiffness, or micro-relief of the

surface. In this case, the sensory experience becomes multi-layered and dynamic. The user does not simply feel the reaction of the material, but gradually learns to recognize it, correlate it with their own actions, and expect a certain response. Responsive fabrics create a feeling of interaction, similar to communication, where the material behaves not as an object, but as an environment with its own logic of reactions.

A comparative analysis of these types of innovative fabrics reveals fundamental differences in their sensory impact (Table 2).

Table 2

Types of innovative fabrics and their key sensory characteristics in the context of emotional design

Dominant sensory channel	Nature of sensory response	Type of user perception	Predominant emotional associations	Design potential
Self-heating fabrics				
Thermal	Gradual, controlled heating	Low-profile, background	Security, comfort, stability	Creating lasting emotional comfort
Color-changing fabrics				
Visual	Visible change in color or shade	Instant, noticeable	Novelty, playfulness, surprise, sometimes tension	Communication of states through visual signals
Responsive fabrics				
Multisensory	Combined reaction (heat, texture, shape)	Processual, interactive	Engagement, control, curiosity	Creating scenarios for interaction with clothing
Traditional functional fabrics (for comparison)				
Tactile	Static action	Passive	Neutral comfort	Support for basic convenience

Source: author's own development

Self-heating materials act primarily at the level of prolonged physical contact and form a background of emotional comfort. Color-changing fabrics appeal to the sense of sight, creating instant, intense emotional signals. Responsive fabrics combine several sensory channels and build a complex, procedural experience of interaction. In each case, the material plays a different emotional role and requires different design integration strategies [5].

The dynamic properties of innovative fabrics change the very nature of a person's emotional interaction with clothing [6]. While traditional materials appeal to a sense of stability, “smart” fabrics introduce an element of changeability, and therefore time, into the bodily experience. It is this temporary, procedural nature of interaction that becomes a key factor in shaping the user's emotional responses. Emotion arises not at the moment of first contact, but at the moment of transformation – when the fabric begins to behave differently than expected.

One of the basic reactions to the dynamics of the material is a feeling of comfort, which takes on a new meaning in the context of adaptive clothing. Comfort ceases to be a static state and becomes a process of constant adjustment. Adjustable heat, gradual changes in density, or reactions to body temperature create the effect of the material “adapting” to the user [5]. Such comfort often does not require conscious awareness. It works in the background, stabilizing the emotional state and reducing stress levels. At the same time, excessive or sudden dynamics can destroy this feeling, turning adaptability into a source of sensory overload. Thus, comfort in the context of dynamic fabrics is the result of a balance between the reaction of the material and human sensitivity.

Closely related to comfort is the feeling of security that comes from the predictability of fabric behavior [8]. Self-heating or stabilizing materials can create a feeling of care, as if the clothing “takes care” of the body in adverse conditions. This effect is particularly noticeable in situations of cold, physical exertion, or emotional stress. However, safety is a fragile emotion. If the dynamics

of the fabric are perceived as autonomous or uncontrolled, it can cause anxiety. A material that reacts without apparent logic ceases to be associated with protection and begins to be perceived as a potential threat. In this context, emotional safety directly depends on the user's ability to interpret the behavior of the material.

The feeling of control is another key dimension of the emotional response to dynamic fabrics. When a person understands what triggers the change in the properties of the material, they feel involved in the process. Control can be direct – through settings or mode selection – or indirect, when the user learns to “read” the fabric's reactions through experience [6]. In the absence of such cues, dynamic material can be perceived as an independent agent acting according to its own rules. This shifts the emotional balance from confidence to caution. Thus, control in interaction with “smart” fabrics has not only a functional but also a deeply emotional meaning.

The emotion of novelty, which is often the first reaction to the dynamic properties of the material, requires separate analysis. A change in color, a moving surface, or an unexpected tactile response evoke interest, surprise, and a sense of play [10]. Novelty enhances user engagement and stimulates exploratory behavior. However, this effect has a limited time resource. With habituation, novelty either transforms into comfort and control, or loses its appeal and begins to irritate. That is why the emotional value of dynamic fabrics cannot be based solely on the effect of surprise.

In summary, it should be noted that the dynamic properties of fabrics form a complex configuration of emotional reactions in which comfort, safety, control, and novelty interact with each other [13]. Their balance is determined by the intensity of changes, their predictability, and the user's ability to interpret the behavior of the material. In this context, dynamic clothing ceases to be a neutral object and becomes an emotionally active environment. This is precisely what

makes the analysis of emotional reactions a necessary step in understanding the role of "smart" fabrics in contemporary fashion design.

The integration of innovative materials into contemporary fashion design requires a rethinking of the very status of technology [13]. In the context of emotionally oriented design, it ceases to be a self-sufficient marker of progress and begins to act as an intermediary between human bodily experience and the designer's idea. That is why the key task is not to demonstrate the technical capabilities of the material, but to form a scenario of interaction that corresponds to the psychological sensitivity of the user and supports their emotional balance.

The first conceptual guideline in this process is human-centeredness. The design of "smart" clothing should be based on the assumption that technology is not neutral: it always evokes a certain emotional response. A material that changes, heats up, or reacts to touch directly interferes with a person's personal space [1]. Therefore, the integration of innovations should begin with an analysis of what emotions are desirable in a specific context of use—calming, support, concentration, or, conversely, stimulation and a sense of play.

An equally important guideline is the predictability of dynamics. The psychological safety of the user largely depends on how understandable the logic of the material's behavior is [7]. If dynamic changes occur for no apparent reason, they can be perceived as intrusive or disturbing. On the other hand, a clear connection between user action, environmental conditions, and fabric response builds trust. In this sense, the designer is not only the author of the form, but also the translator of technology into the language of sensations.

The principle of dosing sensory impact deserves special attention. Innovative fabrics often tempt with excessive activity – bright visual effects, sharp changes in temperature or texture [6]. However, human psychological sensitivity implies limited resources of perception. Emotionally balanced design takes into account the possibility of sensory fatigue and leaves room for adaptation. In this

case, technology does not dominate, but “steps back,” allowing the user to maintain a sense of control over their own physical experience.

Table 3

Conceptual guidelines for integrating innovative materials into fashion design

Conceptual guideline	Design solution	Expected emotional effect
Human-centeredness	Designing with consideration for the user's physical and emotional experience	Sense of acceptability, psychological comfort
Predictability of dynamics	Clear logic of material reactions, understandable sensory signals	Trust, reduced anxiety
Dose of sensory stimulation	Limited intensity of changes, possibility of habituation	Stability, avoidance of overload
Contextual relevance	Alignment of dynamic effects with usage scenarios	Emotional appropriateness, absence of irritation
Co-creation with the user	Customizable modes, personalization of material responses	Sense of control, engagement
Transparency of technology	Visual or tactile cues about how the material works	Sense of security and confidence

Source: author's own development

The next conceptual guideline is the correspondence of the emotional effect to the context of use. The same material can evoke opposite reactions depending on the situation [8]. Dynamic color in stage or experimental clothing is perceived as an expression of creative freedom, while in everyday or work contexts, it is perceived as a distraction. Therefore, the integration of technology into fashion design must take into account the scenarios in which the clothing will be worn and the expected emotional states of the user, rather than just the aesthetic ambitions of the designer.

The final, but fundamentally important, guideline is to involve the user in co-creation. The ability to adjust the intensity of reactions, select modes, or interpret the behavior of the material creates a sense of personal involvement [8].

This approach shifts the interaction with clothing from the plane of consumption to the plane of experience, where technology strengthens the emotional connection between a person and an object (see Table 3).

In summary, it can be argued that the integration of technological innovations into fashion design should be based on the technical potential of materials and the psychological vulnerability of humans. Conceptual guidelines allow “smart” fabrics to be transformed from a demonstration of engineering capabilities into a tool for creating an emotionally supportive, understandable, and safe design environment.

Conclusions

The study allows us to conclude that the development of “smart” fabrics in modern fashion goes far beyond technological progress and directly affects the sphere of human perception and emotional experience. Innovative materials capable of self-heating, change color, or adaptively react, transform clothing from a static object into a dynamic environment of interaction, in which the material actively participates in shaping the user's physical and psychological sensations.

The study found that the dynamic properties of fabrics have different effects on human emotional responses. The feeling of comfort is formed through adaptability and background support of the physical state; the feeling of safety is formed through the predictability and comprehensibility of the material's reactions. Thus, the emotional impact of “smart” fabrics is multidimensional and depends not only on technology, but also on the way it is integrated into the design.

Systematization of the main types of innovative materials has shown that their difference lies not so much in the engineering mechanism of action as in the nature of sensory contact with humans. Self-heating materials create long-lasting background comfort, color-changing fabrics perform a communicative and signaling function, while responsive fabrics create a procedural, interactive

experience. This confirms the need to move from universal design solutions to contextually and emotionally sensitive design.

The results obtained have both theoretical and practical value. From a theoretical point of view, they deepen the understanding of the role of material in emotional design and expand the interdisciplinary dialogue between fashion, materials science, and psychology. In practical terms, the findings can be used by designers and developers of "smart" clothing to create products that focus not only on innovation but also on the emotional well-being of the user. Further research should be directed toward empirical verification of users' emotional reactions in real-life scenarios of wearing adaptive clothing.

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